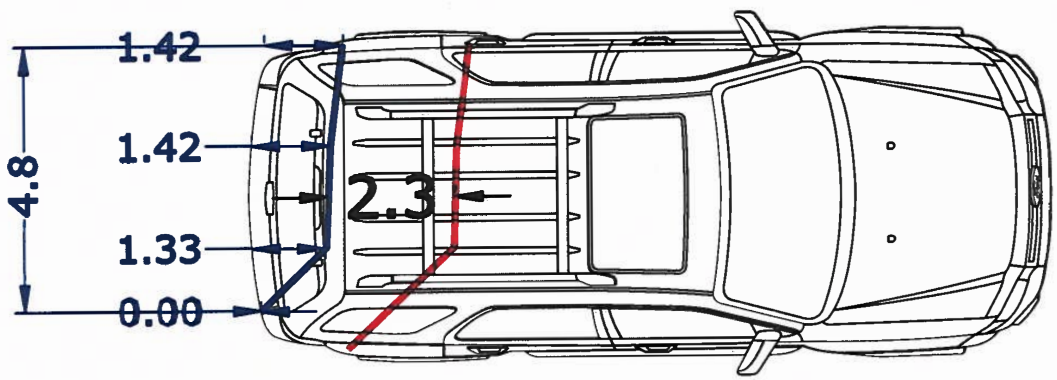
EXHIBIT 23

10519
Calculated Stock Vehicle Crush

ΔCrush ≈ -2.3 feet



2008 Ford Escape 4x2

Red: Accident Damage
Blue: Calculated Damage

1:3

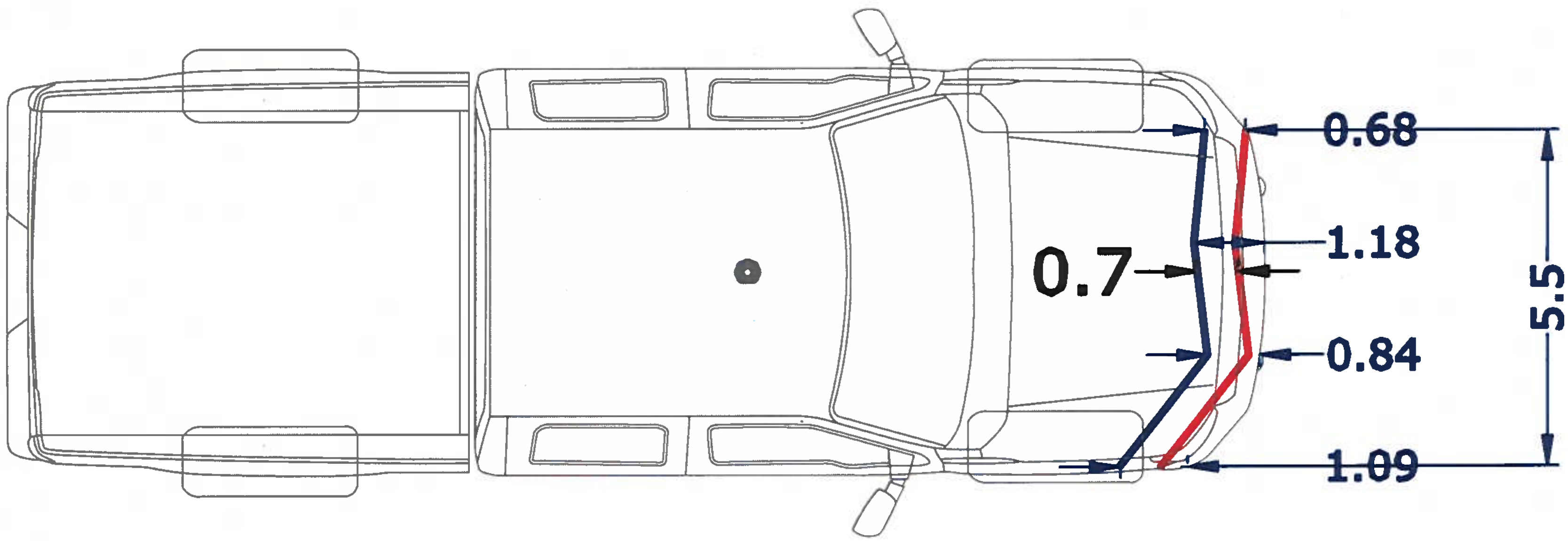
BRYSON 003990

EXHIBIT
7

10519

Calculated Stock Vehicle Crush

ΔCrush ≈ +0.7 feet



2016 Ford F250 SD Crew Cab

Red: Accident Damage
Blue: Calculated Damage

1:3

10519 - Crush from Closing Speed

SAE 2000-01-1318 Derivation of Closing Speed as a Function of Dissipated Energy
Traffic Crash Reconstruction, Northwestern University Center for Public Safety

A
Vehicle 1: 2016 Ford F250 - Front

$M_A := 8.1\ in = 0.7\ ft$

$A_A := 520\ \frac{lbf}{in}$

$B_A := 170\ \frac{lbf}{in^2}$

$W_A := 5.5\ ft$

$C1_A := 0\ in + M_A = 0.68\ ft$

$C2_A := 6\ in + M_A = 1.18\ ft$

$C3_A := 2\ in + M_A = 0.84\ ft$

$C4_A := 5\ in + M_A = 1.09\ ft$

$\theta_A := 0\ deg$

$$G_A := \frac{A_A^{\ 2}}{2 \cdot B_A}$$

$$c_{ave\_A} := \frac{1}{6} \cdot \left(C1_A + 2\ C2_A + 2\ C3_A + C4_A\right)$$

$$c_{square\_A} := \frac{1}{9} \cdot \left(C1_A^{\ 2} + 2\ C2_A^{\ 2} + 2\ C3_A^{\ 2} + C4_A^{\ 2} + C1_A \cdot C2_A + C2_A \cdot C3_A + C3_A \cdot C4_A\right)$$

$$\Theta_A := 1 + \tan\left(\theta_A\right)^2$$

$$E_A := W_A \cdot \left(A_A \cdot c_{ave\_A} + \frac{B_A}{2} \cdot c_{square\_A} + G_A\right) \cdot \Theta_A$$

B
Vehicle 2: 2008 Ford Escape - Rear

$M_B := -28.0\ in = -2.3\ ft$ $\quad M_{Bumper} := 5\ in$

$A_B := 410\ \frac{lbf}{in}$

$B_B := 177\ \frac{lbf}{in^2}$

$W_B := 4.8\ ft$

$C1_B := 40\ in + M_B + M_{Bumper} = 1.42\ ft$

$C2_B := 40\ in + M_B + M_{Bumper} = 1.42\ ft$

$C3_B := 39\ in + M_B + M_{Bumper} = 1.33\ ft$

$C4_B := 0\ in$

$\theta_B := 0\ deg$

$$G_B := \frac{A_B^{\ 2}}{2 \cdot B_B}$$

$$c_{ave\_B} := \frac{1}{6} \cdot \left(C1_B + 2\ C2_B + 2\ C3_B + C4_B\right)$$

$$c_{square\_B} := \frac{1}{9} \cdot \left(C1_B^{\ 2} + 2\ C2_B^{\ 2} + 2\ C3_B^{\ 2} + C4_B^{\ 2} + C1_B \cdot C2_B + C2_B \cdot C3_B + C3_B \cdot C4_B\right)$$

$$\Theta_B := 1 + \tan\left(\theta_B\right)^2$$

$$E_B := W_B \cdot \left(A_B \cdot c_{ave\_B} + \frac{B_B}{2} \cdot c_{square\_B} + G_B\right) \cdot \Theta_B$$

Crush Energies

$E_A = \left(101.3 \cdot 10^3\right)\ ft \cdot lbf$ $\qquad E_B = \left(121.1 \cdot 10^3\right)\ ft \cdot lbf$

$$ForceRatio := \frac{\left(\frac{W_A}{\cos\left(\theta_A\right)} \cdot \left(A_A + B_A \cdot c_{ave\_A}\right)\right)}{\left(\frac{W_B}{\cos\left(\theta_B\right)} \cdot \left(A_B + B_B \cdot c_{ave\_B}\right)\right)} = 1.00$$

10519 - Crush from Closing Speed

	A Vehicle 1: 2016 Ford F250	B Vehicle 2: 2008 Ford Escape
Weight:	$w_A := 8485\ lbf$	$w_B := 3743 \cdot lbf$
Mass:	$m_A := \frac{w_A}{g}$	$m_B := \frac{w_B}{g}$

Restitution

$$e := 0.1$$

Closing Speed

$$E_c := \left(E_A + E_B\right)$$

$$V_c := \sqrt{\frac{2 \cdot E_c \cdot \left(m_A + m_B\right)}{m_A \cdot m_B \cdot \left(1 - e^2\right)}}$$

$$V_c = 51\ mph$$

Expert AutoStats®

Version 6.1.1

QUEST ENGINEERING & FAILURE ANALYSIS INC
1937 RAYMOND DIEHL ROAD
TALLAHASSEE FL 32308

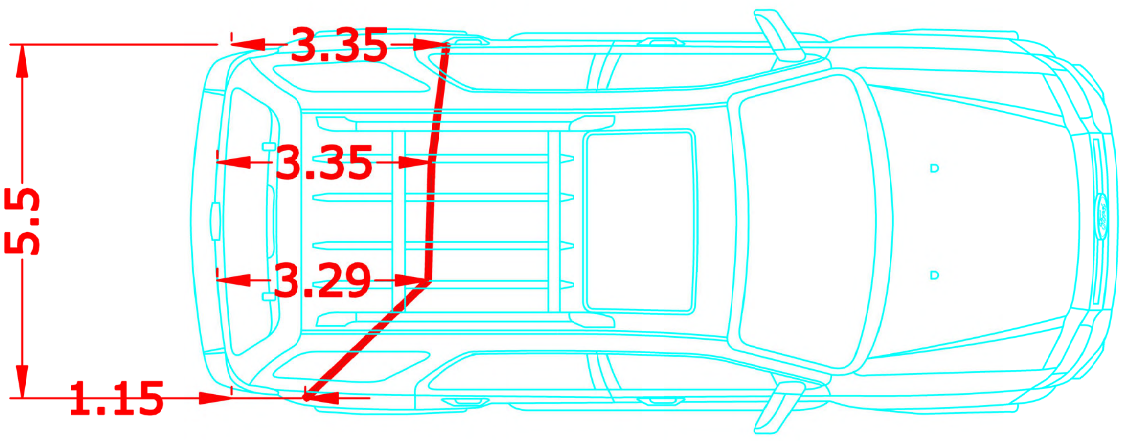
6/8/2023

2010 FORD ESCAPE 4 DOOR 4X2 UTILITY

Curb Weight:		3368	lbs.	1528	kg.
Curb Weight Distribution -	Front:	57	% Rear:	43	%
Gross Vehicle Weight Rating:		4500	lbs.	2041	kg.
Number of Tires on Vehicle:		4			
Drive Wheels:		FRONT			

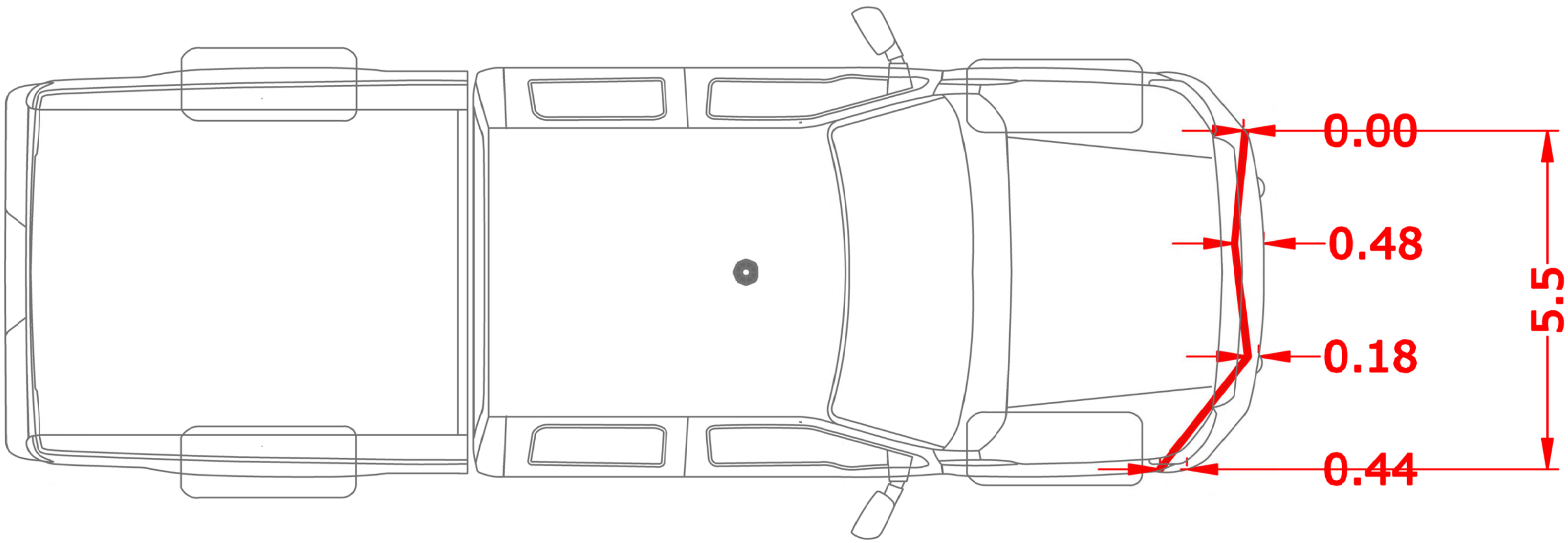
Horizontal Dimensions	Inches	Feet	Meters
Total Length	175	14.58	4.44
Wheelbase:	103	8.58	2.62
Front Bumper to Front Axle:	34	2.83	0.86
Front Bumper to Front of Front Well:	15	1.25	0.38
Front Bumper to Front of Hood:	8	0.67	0.20
Front Bumper to Base of Windshield:	46	3.83	1.17
Front Bumper to Top of Windshield:	71	5.92	1.80
Rear Bumper to Rear Axle:	38	3.17	0.97
Rear Bumper to Rear of Rear Well:	20	1.67	0.51
Rear Bumper to Rear of Trunk:	5	0.42	0.13
Rear Bumper to Base of Rear Window:	6	0.50	0.15
Width Dimensions			
Maximum Width:	71	5.92	1.80
Front Track:	61	5.08	1.55
Rear Track:	60	5.00	1.52
Vertical Dimensions			
Height:	68	5.67	1.73
Ground to -			
Front Bumper (Top)	26	2.17	0.66
Headlight - center	34	2.83	0.86
Hood - top front:	41	3.42	1.04
Base of Windshield	46	3.83	1.17
Rear Bumper - top:	28	2.33	0.71
Trunk - top rear:	44	3.67	1.12
Base of Rear Window:	48	4.00	1.22

2008 Ford Escape:
Accident Crush



1:3

2016 Ford F250: Accident Crush



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Vehicle Crush Stiffness Coefficients

Neptune Engineering, Inc.

REF NO.	YR	MAKE	MODEL	BODY	TRAN	VIN	WB	WT	V-EFF	STRU	PDOF	%OL	#C's	DDW	FoBP	BBE	X_C	b0	b1	K_v	A	B	TEST#
PickF254A	12	FORD	F250 SuperCrew4Dr	PU	A4	1FT7W2B68CEA63185	172.4	7601	35.0	Front	0	100%	6	71.0	N/A	N/A	22.0	4.3	1.4	220	520	170	A:7623
*4/20/2013							Stnd Weight	7008										4.50	Default Value For "b0"				

Liability Disclaimer

The data supplied with this publication is based upon the measurements as reported by the respective source of said measurements. Neptune Engineering, Inc. makes no warranties, either expressed or implied, with respect to the accuracy of said measurements. Neptune Engineering, Inc. makes no warranties, either expressed or implied, with respect to this publication, or with the data supplied with this publication, its quality, performance, merchantability, or fitness for any particular purpose. The entire risk as to its quality and performance is with the buyer. In no event will Neptune Engineering, Inc. be liable for direct, indirect, incidental, or consequential damages resulting from any data presented in the publication, even if Neptune Engineering, Inc. has been advised of the possibility of such damages.

The proper use of the data contained in this publication requires a thorough understanding of vehicle dynamics. The user should recognize that there is a degree of variance in the level of damages sustained by "identical" vehicles during controlled barrier collisions. The user also should recognize that the potential variance in the level of damages sustained during a "real-world" collision is even greater. Sound engineering judgment, therefore, should be used when applying the enclosed data in the reconstruction of "real-world" collisions. The user must accept full responsibility for any decisions that are based, in whole or in part, upon information obtained by using this data. It is important that the user of this data understand how the coefficients were determined. It is important that such knowledge be considered when rendering the engineering judgments required during their use. The coefficients are determined using concepts and procedures presented in Society of Automotive Engineers papers 920607, 940913, 950358, 960896, 980024 & 1999-01-0105. Please contact Neptune Engineering, Inc. should you have any questions.

APPENDIX

Table A1. Front, rear and side stiffness values by class of passenger car. The mean, standard deviation (SD), and number of samples (n) for each category are given.

		Passenger Cars							
		Subcompact		**Compact**		**Mid-Size**		**Large**	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Wheelbase (in)		96.7	4.5	100.6	3.3	107.1	2.7	112.4	3.0
Curb Weight (lb)		2363	399	2684	299	3190	263	3633	273
Front	A (lb/in)	230	29	253	35	292	38	282	40
	B (lb/in^2)	79	13	87	19	98	20	87	21
	n	16		36		32		19	
Rear	A (lb/in)	202	78	193	45	213	48	182	26
	B (lb/in^2)	73	44	56	21	59	25	37	4
	n	8		20		11		2	
Side	A (lb/in)	97	23	92	13	95	17	94	5
	B (lb/in^2)	73	33	65	14	59	18	51	6
	n	2		9		16		6	

Table A2. Front, rear and side stiffness values by class of light truck. The mean, standard deviation (SD), and number of samples (n) for each category are given.

		Light Trucks									
		Small Pickup		**Standard Pickup**		**SUV**		**Van**		**Minivan**	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Wheelbase Min(in)		105.9	2.7	118.5	8.6	107.8	9.5	130.5	7.0	115.4	3.7
Wheelbase Max(in)		121.8	8.0	134.5	9.9	109.4	9.8	144.3	8.1	117.5	3.4
Curb Weight (lb)		2978	391	4097	832	4235	858	4779	464	3900	390
Front	A (lb/in)	290	45	341	91	381	61	390	10	330	64
	B (lb/in^2)	109	26	122	52	137	42	150	15	108	28
	n	6		25		48		4		12	
Rear	A (lb/in)	237	14	241	86	410	110	No data available		347	110
	B (lb/in^2)	77	10	74	38	177	71			136	79
	n	4		5		9				4	
Side	A (lb/in)	120	N/A	149	16	147	49	No data available		94	4
	B (lb/in^2)	92	N/A	92	16	112	49			47	0
	n	1		3		10				2	

SAE INTERNATIONAL

Increase in Vehicle Front, Rear and Side Stiffness Coefficients in the Past Twenty Years Necessitates New Representative Database

2014-01-0351

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Hayes & Associates

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Abstract

When vehicle-specific stiffness coefficients cannot be acquired, stiffness coefficient values that are representative of the desired vehicle type, class, wheelbase or weight are routinely used for accident reconstructions. Since the original compilation of representative vehicle stiffness data almost 20 years ago, changes in crash testing standards and other safety and technological improvements in vehicular design have affected vehicle stiffness. While generic frontal stiffness data have been recently updated to reflect these vehicular changes, rear and side stiffness data have not. Structural, geometric and inertial data for over 300 passenger cars and light trucks were collected. Among the vehicles targeted were the top-selling cars, SUVs, vans and pickups for model years 1990 to 2012. Results indicated that all vehicle types demonstrated increases in mean stiffness over the time period considered. SUVs were, on average, the stiffest vehicle type in the front, rear and side. There was a correlation between vehicle wheelbase and stiffness, with longer vehicles having greater stiffness than shorter vehicles. Vehicle class also affected stiffness. In the front and rear, mid-size passenger cars had the greatest mean “A” and “B” stiffness coefficients of all passenger cars. By contrast to the front and rear, mean side stiffness of all passenger cars classes was similar. In conclusion, the updated structural stiffness and geometric data presented here for the front, rear and side, provide an accurate representation of today's market for use in crash reconstructions.

Introduction

To quantify the energy needed to cause residual crush deformation to a vehicle during a collision, a mathematical vehicle structure model can be used [1, 2, 3, 4, 5]. This is a well-accepted means to assess fundamental collision parameters, including the pre-impact collision speed and vehicle change-in-velocity (“delta-V”). The specific structural parameters required for damaged-based reconstruction are referred to as the “A” and “B” stiffness coefficients. These “A” and “B” stiffness coefficients correspond to the force (per inch of damage width [lb/in]) that is required to initiate permanent damage and the ensuing linear stiffness (crush resistance) associated with the residual crush depth (per inch of damage width [lb/in2]), respectively (Fig. 1).

For practical implementation of this method, vehicle stiffness coefficients that are applicable to the vehicle under consideration must be obtained. Often, stiffness coefficients for specific vehicles are available directly from various publicly-accessible databases (e.g., Neptune Inc., ARC Network, StiffCalcs) or can be calculated from data associated with controlled crash tests. However, periodically, vehicle-specific stiffness coefficients cannot be acquired. Under these conditions, stiffness coefficient values that are representative of the desired vehicle type, class, wheelbase or weight are routinely used.

The original compilation of representative vehicle stiffness data was published almost 20 years ago [6]. Over this time period, vehicle type, governmental and private safety standards, along with manufacturing processes and materials have evolved, influencing structural stiffness properties. Specifically, vehicles have tended, on average, to become larger and heavier; unibody design/construction has increased; and pickups and sport utility vehicles (SUV) have become a greater percentage of the vehicle fleet. For example, the average curb weight of passenger cars has steadily increased from a low of 2,805 lbs in 1987 to 3,239 lbs in 2004 [7]. Similarly, the average weight of light trucks (including pickups and sport utilities) has increased from 3,797 lbs to 4,802 lbs from 1987 to 2004. Crash testing standards have also changed since the mid-1990's, with the addition of new tests such as the Insurance Institute for Highway Safety's frontal offset deformable barrier test in 1995. Vehicular design changes are driven, in part, by changes in such standards, as well as other safety and technological improvements [8]. Thus, representative structural stiffness coefficients derived from a population of pre-1996 vehicles may